Transistor Circuit Design Made Easy

PART I

By M. C. HATELY, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E. (G3HAT)*

OFTEN amateurs neglect using transistors where they would seem to be of real advantage. Their robustness, efficient power conversion and small size, make them ideal for microphone pre-amplifiers, loudspeaker amplifiers, modulators for mobile equipment and so on. Perhaps the main reason they are not used by more amateurs is that the published data seems difficult to understand, or perhaps because the text books on transistors seem to be packed with long algebraic expressions. It is hoped that this series will dispel these mysteries and enable readers to use transistors freely in home-built equipment.

This article and two articles to follow will deal with the design of audio amplifiers of several useful types. In the present article a method will be described for designing a voltage amplifier of any desired gain: in the second, current amplifiers and push-pull amplifiers will be shown: in the third, some power amplifiers will be designed and there will be some general hints on testing and fault finding. All this will be done using down-to-earth, step-by-step methods with a minimum of calculation and fuss. There will be short appendices to each article to show the mathematically minded how the formulae are obtained. Readers who have bought surplus transistors about which they know nothing but the base connections, will find that it will be possible to use them in most of these designs.

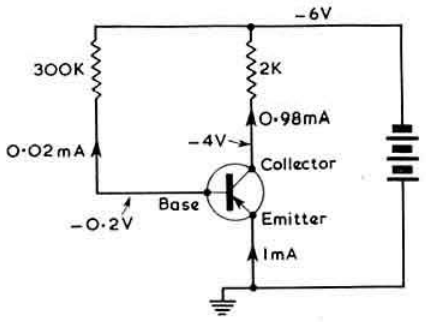

Fig. 1. Simplified circuit arrangement.

* *87 Warden Avenue, South Harrow, Middlesex.*

† Nearly all transistors used at present are *p-n-p* types which need the collector negative with reference to emitter. *N-p-n* transistors are the reverse of this but they are rarely encountered at the present time.

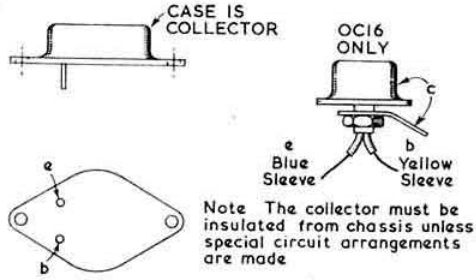

Fig. 3. Base connections of power transistors.

First of all, so that everyone is thinking the same way, an explanation of a few fundamentals is necessary. What is the transistor anyway?

Primarily it is a *current* amplifier. Most transistors use a *negative* voltage supply†. The signals are put *in* at the *base* and arrive amplified at the *collector*. The emitter is usually decoupled to earth.

With these facts in mind, it is useful to study the circuit in Fig. 1. This shows the symbol for a normal transistor and typical currents and voltages. Notice particularly that the emitter carries both of the other currents, and that the base current is only 1/49 of the collector current. Here is the property of the transistor that is so useful. A tiny current in the base circuit causes many times that current to flow in the collector circuit. To extend the principle to a.c. conditions, a tiny *change* of base current will cause a very much multiplied *change* of collector current. The relation between collector current and base current is called the β (beta) of the transistor, i.e. the current gain of the transistor. In this case $\beta = 49$.

This most important parameter, β, is in some literature also called α' (alpha dashed) or α' or h_{fe}. Notice also the approximate voltages of the base and collector electrodes relative to emitter. In all distortionless circuits the base will be about 0·15 to 0·3V negative of emitter and the collector will be about 3V or more negative of the emitter. (In a.c. work the collector must never approach emitter voltage at any instant or there will be distortion.)

Base connections of most small transistors are shown in Fig. 2. Base connections of power transistors are usually as shown in Fig. 3.

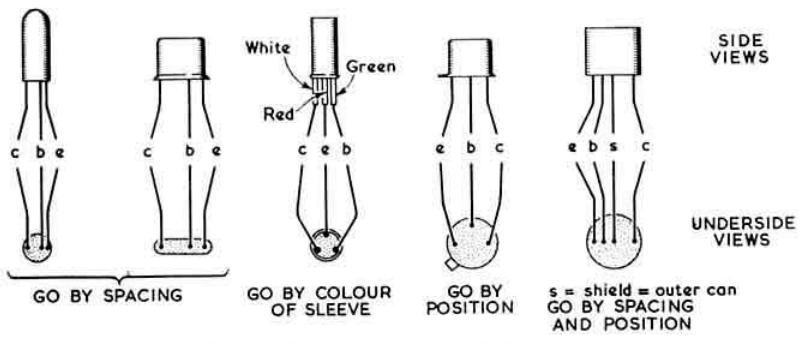

Fig. 2. Base connections of small transistors.

All the disadvantages of the heater circuit of the thermionic valve are absent. There is no delay after switching on, no heater current running to waste and heating up the whole equipment, and there is no hum. There are, however, some attendant disadvantages.

Unfortunately the β changes as the transistor gets warm, and secondly the input terminal (the base) draws a little current, but these troubles are easily overcome by appropriate design.

Data—What to Look for

If information on available transis-

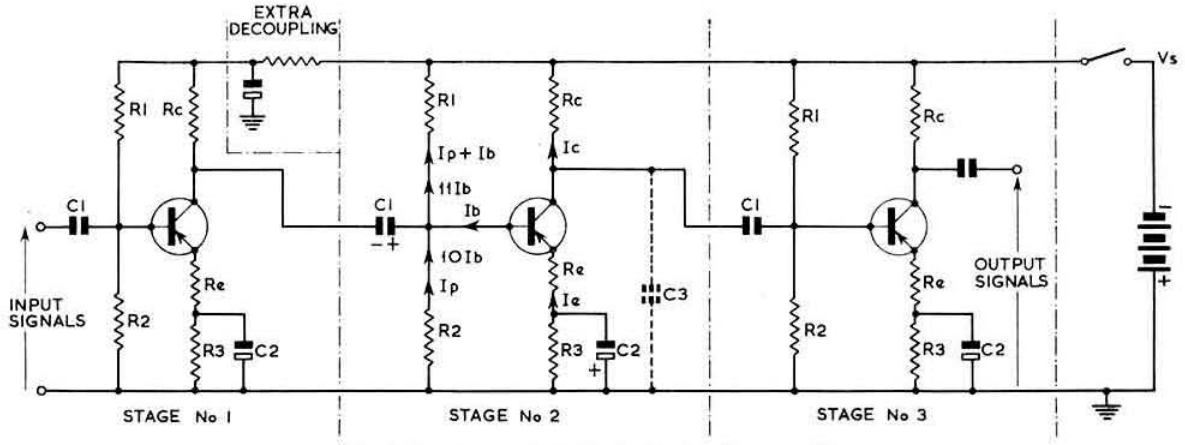

Fig. 4. The general schematic circuit of a voltage amplifier.

tors is obtainable, it is important to know what to look for.

Firstly, see that the collector voltage rating is good enough for the negative h.t. supply—most are suitable for −15V peak. Others are made up to −50V or more. Secondly, see that the collector wattage is reasonable. Most audio transistors will stand 50 milliwatts in their collector; intermediate power, ½ to 1 watt; and power, up to 12 watts (when bolted to a metal cooling fin, or " heat sink "). Thirdly, check that the collector current carrying capacity is adequate. Usually this is more than adequate in all the applications to be discussed. Fourthly, look up the β (or α' or $\bar{\alpha}'$ or h_{fe}). In the circuits to be considered we shall not be restricted by β as long as it is about 20 or more, but the more that is known the better. Most general purpose transistors have β about 40 but they vary among specimens of any one type.

Voltage Amplifier Design

Fig. 4 shows a three-stage amplifier. One complete stage lies between dotted lines. Moving step by step, starting from a design requirement, a simplified procedure is as follows:

(i) Decide the amplification (or gain) that is required overall.

(ii) Break this up into stages of equal gain, and not more than 14 per stage (up to 30 if it is certain the transistors have a β of 100 or more). Remember this is not simply division but finding a root, e.g. 1,000 is produced by three stages of 10 gain or two stages of 31·7.

(iii) Decide on a voltage of supply (Vs). This depends on what is available in a reasonable sized battery and should not be greater than the maximum collector voltage the transistor will stand (say 9V if in doubt).

(iv) Decide on an economical current drain and use this for the collector current I_c. (Do not use less than 300 μA with germanium transistors. One milliamp is ideal.)

(v) Calculate the base current I_b, which will be necessary to cause this I_c to flow. $I_b = I_c/\beta$
If β is unknown, assume it is 30.
Thus a typical value for I_b is 1 mA/30 = 33 μA.

(vi) Drain 10 times this base current down R2 and R1. (So Fig. 4 shows 10 I_b through R2 and 11 I_b through R1.) Call it potentiometer current, I_p, then $I_p = 10\ I_b$.

(vii) Make the emitter voltage, V_e, equal to one-third V supply so $V_e = V_s/3$

(viii) By Ohm's law calculate value of (R_e + R3) $R_e + R3 = V_e/I_c$ approximately.

(ix) Choose R_e so that the voltage across R_e is also one-third V supply. By Ohm's law $R_e = V_s/3I_c$. Use the nearest value higher.

(x) Calculate R_c from the following relationship:
Voltage gain of stage = R_c/R_e or $R_c = R_c/gain$
(Notice that it is not necessary to know β for this.) Use the nearest standard value lower.

(xi) Find R3 from step (viii) by subtraction. Use nearest standard value.

(xii) Calculate R2 from fact that the voltage at the base is

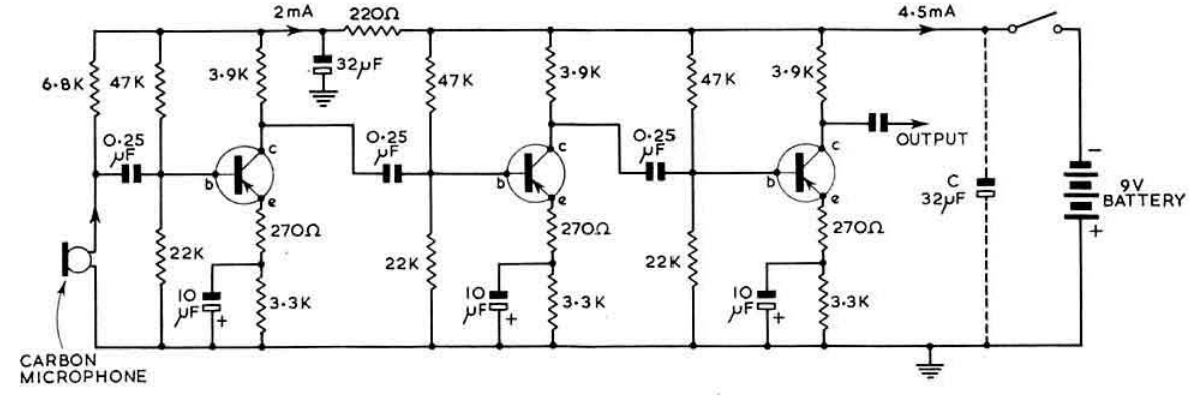

Fig. 5. Full circuit of the worked example (voltage amplifier. Gain = 2000).

approximately V_e so by Ohm's Law R2 $= V_e/I_p$. Use nearest standard value higher.

(xiii) Calculate R1 from Ohm's Law

$$R1 \simeq (V_s - V_e)/I_p.$$

Use nearest standard value higher.

Make C2 at least 10 μF (which need only have a working voltage of V_e or more but beware polarity).

Make C1 $= 0{\cdot}25\,\mu$F

Put decoupling in the h.t. supply between every pair of stages. The resistors should drop only 0·5V or so (due to the total current to all the stages ahead) and the capacitors should be about twice the capacity of C2 or larger if the space can be afforded. The polarity of electrolytic capacitors must be carefully observed.

Worked Example

A carbon microphone can give 1 mV but 2V is needed for a modulator input.

(i) A gain of 2,000 is therefore required. Supposing GET103 transistors are available, the following information is required from the data sheet.

$V_{c\,max} = -30$V
$W_{c\,max} = 200$ mW
$I_{c\,peak\,max} = 1$ amp.
$\beta = 60$ (average)

(ii) Three stages with an overall gain of 2,000 is 12·6 per stage.

(iii) Working from −9V.

(iv) Decide average current: 800 μA.

(v) Therefore base current $= 800/\beta = 800/60 = 13{\cdot}3\,\mu$A.

(vi) $I_p = 133\,\mu$A.

(vii) $V_e = 9/3 = 3$V.

(viii) $R_e + R3 = 3\text{V}/800\,\mu\text{A} = 3{\cdot}75$K ohms.

(ix) $R_e = 3\text{V}/800\,\mu\text{A} = 3{\cdot}75$K ohms (use nearest higher value: 3·9K ohms).

(x) $R_e = 3{\cdot}9\text{K}/12{\cdot}6 = 310$ ohms (use 270 ohms).

(xi) R3 $= 3{\cdot}75\text{K} - 270 = 3{\cdot}48$K ohms (use 3·3K ohms).

(xii) R2 $= 3\text{V}/133\,\mu\text{A} = 22{\cdot}6$K ohms (use 22K ohms).

(xiii) R1 $= (9 - 3)\text{V}/133\,\mu\text{A} = 6\text{V}/133\,\mu\text{A} = 45$K ohms (use 47K ohms).

Circuit is then as shown in Fig. 5.

Footnotes

1. C may be added to overcome high internal resistance which develops in batteries. Value of C = 25 μF or more.
2. A carbon microphone is ideally used with transistor circuits because the usual transformer may be omitted and microphone current can be bled from the transistor supply voltage. When used a foot or so from the mouth a carbon microphone is capable of fairly good quality.
3. If it is desired to design the frequency response of the amplifiers, a method is given at the end of the appendix.

Appendix

Step (iv). I_c should be 10 times I'_{co} (the collector leakage current) or 10 times βxI_{co} (the base leakage current). Use at least 300 μA for germanium transistors or 30 μA for silicon transistors.

Step (viii). Accurately, $R_e + R3 = V_e/I_e$

But $I_e = I_c + I_b$
$= I_c + I_c/\beta$
$= I_c(1 + 1/\beta)$ as β usually 30 or so
$= I_c(1 + 1/30)$
$\simeq I_c$

So $R_e + R3 \simeq V_e/I_c$

Step (x). $\textit{Voltage gain} = \dfrac{\textit{Voltage out}}{\textit{Voltage in}}$

Referring to small changes of current and voltage only:

Voltage out $v_o = R_c i_c$
$= R_c \beta i_b$

Voltage in $v_i = R_e i_e$
$= R_e(i_b + i_c)$
$= R_e(i_b + \beta i_b)$
$= R_e i_b(1 + \beta)$

since the base to emitter voltage hardly changes, nearly all the signal appears on the emitter in this circuit.

So $v_o/v_i = R_c i_b \beta / R_e i_b(\beta + 1)$ But β is much greater than 1

Or $v_o/v_i \simeq R_c/R_e$

So voltage gain $\simeq R_c/R_e$

The output impedance Z_o at the collector is approximately

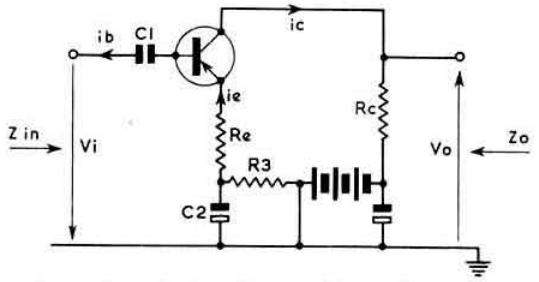

Fig. 6. Theoretical small signal circuit of one stage.

R_c since the collector is a current source of resistance about 50K ohms.

The input impedance Z_{in} at base is

$Z_{in} = v_i/i_b$
$= i_e R_e/i_b$
$= (\beta + 1) i_b R_e/i_b$
$= (\beta + 1) R_e$

So $Z_{in} \simeq \beta R_e$

provided R_e is greater than 50 ohms for a small audio transistor or 5 ohms for a power transistor. Here the base input resistance of the transistor is neglected. It is usually 60 ohms or more and *adds* to the calculated input resistance.

Frequency Response

(*a*) *Low Frequency End.* Controlled by C1 and C2. It is usually best to make C2 too large and control the l.f. end response by C1. See Figs. 6 and 7.

The rule is 3db at frequency (fl) *per stage* where

$$C1 = 1/2\pi fl \beta R_e \text{ Farad}$$

(or 1db per stage at twice this frequency) so if there are three stages it is 9db down at this frequency.

$C2$ must be much greater than $C2 = 1/2\pi fl R_e$ Farad.

$C1$ may be electrolytic with negative side to collector and positive to base.

(*b*) *High Frequency End.* Most ordinary transistors lose their β about 15 to 20 kc/s—but if required to fall off before this frequency add a capacitor C3 as shown dotted in Fig. 4. Each stage so treated will be 3db down at a frequency (f_h) where

$$C3 = 1/2\pi f_h \beta R_e$$

or 1db per stage so treated at a half this frequency.

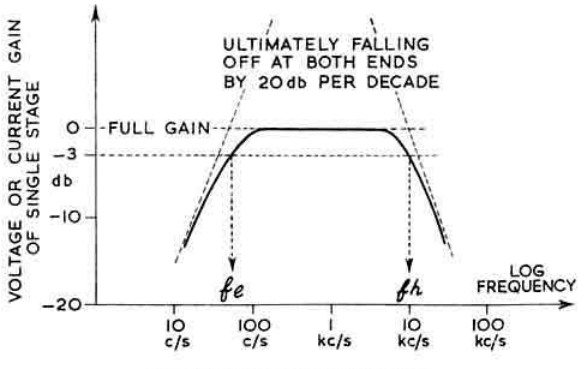

Fig. 7. Band edge considerations.

Transistor Circuit Design Made Easy

PART 2

By M. C. HATELY, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E. (G3HAT)*

IN the first article in this series† a method of designing transistor voltage amplifiers was described. Amplifiers of this type are intended to work from a low resistance source into a load with a high resistance. To obtain appreciable power gain and low distortion, a voltage amplifier must therefore have a fairly high input resistance and a reasonably low output resistance. In circuits already described amplifier input and output resistances of about 10K ohms are easily possible with germanium transistors while values of 100K ohms can be achieved with silicon transistors using the same design methods. Silicon transistors are available from at least one manufacturer at prices similar to those of germanium transistors.

The present article contains design methods and examples of current amplifiers and push-pull amplifiers. Current amplifiers are not easy to produce in valve designs, so the use of transistors here considerably widens the scope of the designer. Push-pull circuits are useful for mixers (audio variety: really " adders ") and for low hum pre-amplifiers.

Current Amplifier Design

A current amplifier has a low input resistance and a high output resistance and operates most efficiently from a source of high resistance into a load of low resistance. A typical amateur application might be from a high impedance dynamic microphone into a low impedance tape recorder head.

A typical circuit is shown in Fig. 8 and will be seen to be almost identical to the general voltage amplifier described in Part 1. It should be noted, however, that the single stage includes the collector resistance of one transistor and the emitter resistor of the next. Design steps are as follows:

(i) Decide the current amplification or gain needed overall.

(ii) Break this up into stages of equal gain as for voltage amplification, allotting a gain of not more than 15 per stage.

Steps (iii) to (ix) inclusive are as for voltage amplifiers.

(x) Calculate R_e from: *Current Gain of one stage* $= R_c/R_e$ or $R_e = R_c/$*Current Gain*.

Note this is also independent of β and so, as with voltage amplifiers, almost any transistor can be used to get calculable current gain.

Steps (xi) to (xiii) inclusive are as for voltage amplifiers.

(xiv) Check the power dissipation in the collector of last transistor in the amplifier. This is obtained by (I_c) $\times$ (V *collector-to-emitter*) or $W_c = I_c V_{ce}$

Such dissipation must be less than the rated dissipation for the transistor in the condition of use. (Ambient temperature, and cooling fin arrangement, etc.)

The design of Fig. 8 is complete for all intermediate stages. The last stage should have a collector resistance (R_o) at least 10 times higher than the load impedance, provided this is not making R_o greater than R_c. A large value is unwise since the voltage swing that R_o causes the collector to undergo, may rise to the base voltage on peaks of signal, and distortion will be caused. If a load of more than 300 ohms impedance is to be current fed, it is necessary to use a reasonably high supply voltage.

The current gain of the first stage depends on the ratio of source resistance (or impedance) and emitter resistance R_{e1}

$$\textit{Current Gain} = R_s/R_{e1}$$

If the source impedance at working frequencies is not known, it can be made fairly high by means of an added series resistance, say 10K ohms. If R_{e1} is made 1K ohms, then this stage will give a current gain of at least 10 and more if the source resistance is high. Capacitor values are chosen in the manner described in Part 1 for voltage amplifiers.

Worked Example

A dynamic microphone of 10K ohms output impedance is to feed a 30 ohms impedance recorder head. The peak output of the microphone is 5 mV and the recorder head requires a peak current of 4 mA.

An output of 5 mV from a 10K ohms source represents a current of 5 mV/10K ohms $= 5 \times 10^{-3}/10^4 = 5 \times 10^{-7}$ A $=$ 0·5 μA. This may seem a ridiculously small signal to amplify, but it is perfectly feasible to do so. The data for the GET106 low noise transistor shows that 20db signal-to-noise ratio may be obtained with an input current of 2 millimicroamps; an ordinary transistor such as the GET103 is only 5db worse.

Working through the steps already described:

(i) The current gain required is 4 mA/0·5 μA
$= 4 \times 10^{-3}/5 \times 10^{-7} = 8 \times 10^3 = 8{,}000$

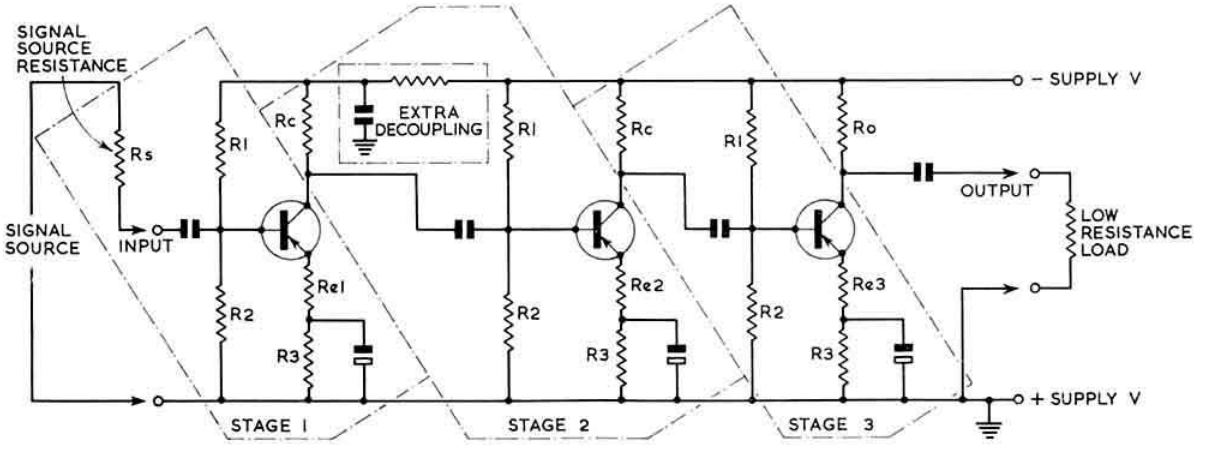

Fig. 8. The general schematic of a current amplifier

* *87 Warden Avenue, South Harrow, Middlesex.* † *April 1962.*

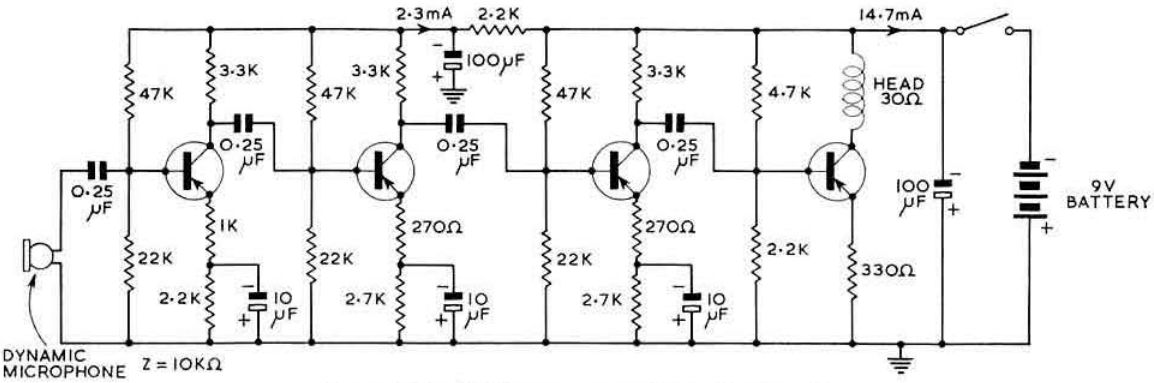

Fig. 9. Full circuit of the current amplifier worked example.

(ii) The fourth root of this is 9·5, so four stages of current gain of 9·5 each are required. The last stage much be capable of carrying 4 mA peak current without distortion so should be set to pass 10 mA as a steady current. (A more sophisticated design would employ negative feedback over the whole amplifier but this will serve for an example.)

(iii) A 9V supply can be chosen.

(iv) The collector current chosen I_c = 1 mA except for the fourth stage which takes 10 mA.

(v) Base current $I_b = I_c/\beta$
= 1/60 = 13·3 μA for the first three stages
= 10/60 = 133 μA for the fourth stage.

(vi) Potentiometer current
= 133 μA for stages 1-3
= 1·33 mA for stage 4.

(vii) Emitter voltage = 9V/3 = 3V

(viii) R_e + R3 = 3V/I_e
= 3/1 mA = 3K ohms for stages 1-3.
3/10 mA = 300 ohms for stage 4.

(ix) Collector resistance R_c = 9/3 × 1 mA = 3K ohms (use 3·3K ohms) for stages 1-3. R_c of stage 4 to be 10 times load impedance, i.e. 300 ohms so use 330 ohms; or use the tape recorder head alone in the negative h.t. line.

(x) Emitter resistance $R_e = R_c/GAIN$
= 3K/9·5 = 316 ohms (use 270 ohms).

(xi) From (viii) R3 = 3K − 270 = 2·73K ohms (use 2·7K ohms) for stages 1-3. For stage 4, R3 = 300 − 316 ≏ zero ohms.

(xii) R2 = 3V/I_b
= 3V/133 μA = 22K ohms for stages 1-3.
3V/1·3 mA = 2·2K ohms for stage 4.

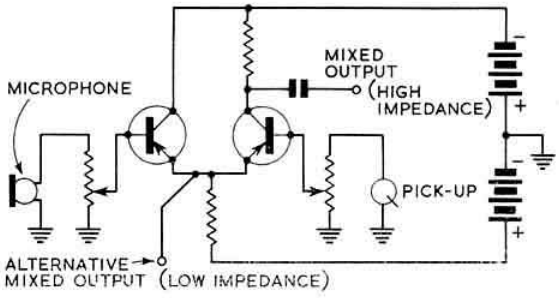

Fig. 10. An audio mixer using emitter coupled pair.

(xiii) R1 = (9 − 3)/I_b
= 6V/133 μA = 45K ohms (use 47K ohms) for stages 1-3.
= 6V/1·3 mA = 4·5K ohms (use 4·7K ohms) for stage 4.

(xiv) $W_c = I_c V_{ce} = 10 \times 10^{-3} \times 3 = 30$ mW for GET103.

The first stage emitter resistor should be a value so that

$$R_s/R_e = 9{\cdot}5$$

that is R_e = 10K/9·5 = 1·04K ohms (use 1K ohms).

So from (viii) R3 = 3K − 1K = 2K ohms (use 2·2K ohms).

The full circuit is shown in Fig. 9.

Push-pull Amplifier Design

Besides the uses for mixing two audio signals to produce an added output, push-pull amplifiers find many other applications. They can be employed as phase splitters for driving a push-pull circuit from a single-ended source—e.g.

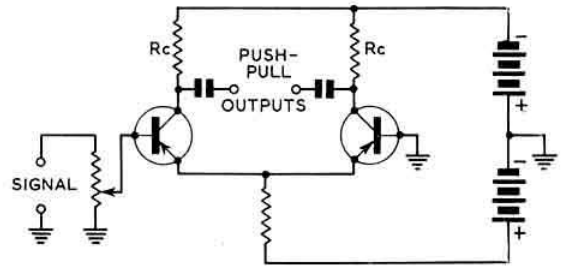

Fig. 11. A phase splitter using emitter coupled pair.

a power amplifier for a modulator in mobile equipment. Push-pull amplifiers also find application in discriminating in favour of out-of-phase signals in the presence of in-phase voltages, e.g. a weak microphone signal on a long twin cable travelling through a hum field.

In all these applications, the use merely determines the connection of the input and output, and not the individual design method. Block schematics are shown in Figs. 10, 11 and 12.

With two batteries as shown, or a grid bias battery with the centre tap earthed, direct connected earth level inputs can be employed for these amplifiers which is another useful feature.

The general one stage push-pull amplifier is shown in Fig. 13 in which the wording of the input and output terminals should be noted. This is to show which way the amplification phase is shifted. A negative going signal on

the lefthand base produces a positive going change on the lefthand collector and vice versa.

Stages may be coupled together to obtain the desired gain as follows:

(i) Decide the overall gain required. (Note that with a transition from push-pull to single ended output only half the possible stage gain is obtained in the last stage.)

(ii) Break up the gain into equal stages by taking a root.

(iii) Decide on a negative supply voltage, and use the same voltage for the positive line (to the emitters via " tail " resistors).

(iv) Decide on an economical current drain I_T and use this for the " tail " current which will be shared by the transistors. A value of 2 mA is ideal for germanium types.

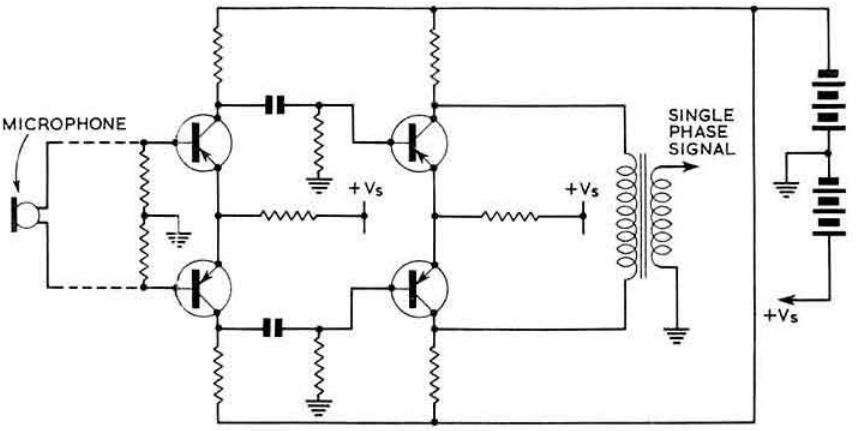

Fig. 12. An anti-hum amplifier using emitter coupled pairs.

(v) Calculate the value of collector resistor R_c so that R_c = Neg. V_s/I_T (use the nearest value higher or lower).

(vi) Calculate the value of R_T, the tail resistor, so that R_T = Pos. V/I_T (use the next value higher).

(vii) Calculate the maximum value of $R_b = R_T\beta/5$ or if β unknown, R_b may be made equal to $6R_T$

R_b may be less than this provided it does not load the previous R_c (or source resistance) too much.

If there *is always* a d.c. connection to earth through the push-pull source, or the circuit is being used as a phase splitter, R_b is unnecessary. It is merely a d.c. path for the base current.

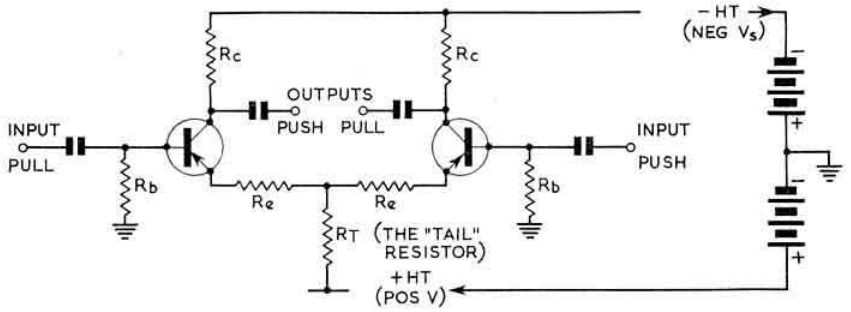

Fig. 13. One stage of a push-pull amplifier. The emitter coupled pair. (Sometimes called the long tailed pair)

(viii) Calculate the value of R_e.
R_e = R_c/*Stage Gain* (use nearest value lower).

(ix) Fit capacitors where necessary to isolate d.c. potentials. Capacitors between stages may be 0·25 μF.

Decoupling capacitors are not often necessary since balanced signals flow in the h.t. lines.

(x) If currents are 10 mA or more, check to ensure collector dissipation is not excessive. The dissipation in the tail and collector resistors should also be checked. Make use of formulae $W = VI$, V^2/R, or I^2R.

Worked Example

Suppose a signal of 3 mV from a dynamic microphone is to be amplified to provide a 2 volt push-pull input signal for a transistor push-pull modulator GET103, transistors are available.

(i) Gain required = $2/3 \times 10^{-3} = 666$.

(ii) Using three stages, the gain of each must be 8·75.

(iii) A 9V battery is to supply the positive and negative h.t. lines (the 2 volt swing required demands about 4 volts for the collector resistance drop).

(iv) The tail current (I_T) can be 2 mA. (It may be wise to use 4 or even 8 mA for the last stage if it has to drive a low impedance.)

(v) R_c = *Neg.* V/I_T = 9V/2 mA = 4·5K ohms (use 4·7K ohms).

(vi) R_T = *Pos.* V/I_T = 9V/2 mA = 4.5K ohms (use 4·7K ohms).

(vii) R_b = 4·7K $\times$ 60/5 = 56K ohms (use 47K ohms).

(viii) R_e = 4·7K/8·75 = 537 ohms (use 470 ohms).

(ix) Use 0·25 μF capacitors between the transistors.

(x) Power in the tail resistor is $I_T^2 \times R_T = (0{\cdot}002)^2 \times 4{\cdot}7$K ohms = 0·08 W which is less than the smallest type of resistor can stand satisfactorily.

The full circuit is shown in Fig. 14.

The arrangement in the emitter circuit of the last part of transistors provides single knob control of amplification which will give a 5 to 1 change of output voltage in both sides. If full control is needed, the 47K ohms resistor following the microphone may be made a potentiometer (log or linear).

Appendix

Step (x) of Current Amplifier Design.

(x) Current gain of a single stage, e.g. stage 2 (Fig. 15).

As before, $Z_{in} = \beta R_e$

$$i_2 = \beta i_1$$

But $\dfrac{i_1}{i_0} = \dfrac{R_c}{Z_{in}}$ or $i_1 = i_0 \dfrac{R_c}{Z_{in}}$

So $i_2 = \beta i_0 R_c/Z_{in}$

$= \beta i_0 R_c/\beta R_e$

$= i_0 R_c/R_e$

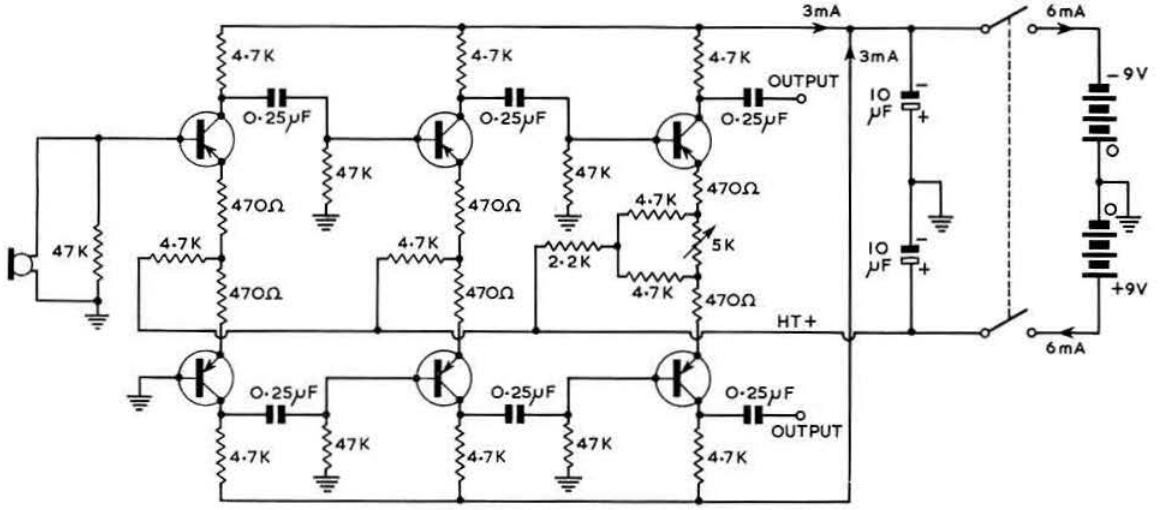

Fig. 14. Three stage push-pull amplifier. Complete circuit of the worked example.

Therefore, current gain for that stage is $\frac{i_2}{i_0} = \frac{R_c}{R_e}$

Steps of Push-Pull Amplifier Design (see Fig. 16).

(v) $\frac{1}{2}$ *Neg.* $V = \frac{1}{2} I_T R_c$

So R_c = Neg. V/I_T

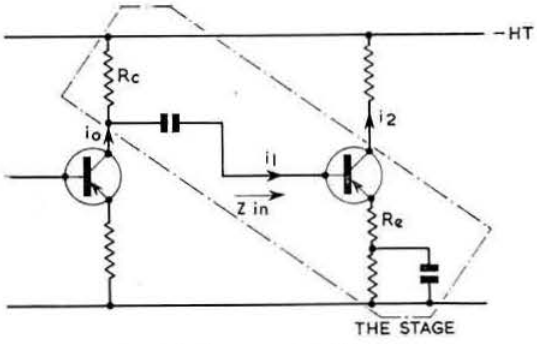

Fig. 15. Basic current amplifier stage.

(vi) For base and emitter potentials to be about earth

$R_T = Pos.\ V/I_T$

(vii) $V_{base} = R_b . \frac{1}{2} I_T . \frac{1}{\beta}$

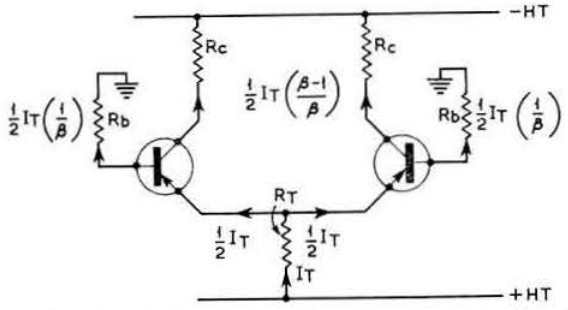

Fig. 16. Biasing for the emitter coupled pair. R_e may be neglected as its value is small.

But $V_{base} + V_{emitter} = Pos.\ V$

V_{base} should not be more than say $\frac{1}{10}$ *Pos.* V in order that the true long tailed pair effect is retained, so

$$R_b . \tfrac{1}{2} I_T . \frac{1}{\beta} = \frac{1}{10} Pos.\ V$$

$$= \frac{1}{10} . \frac{10}{9} I_T R_T$$

So $$R_b = \frac{2\beta}{9} . R_T$$

$$= \frac{\beta R_T}{4{\cdot}5} \text{ or approximately } = R_T \beta / 5$$

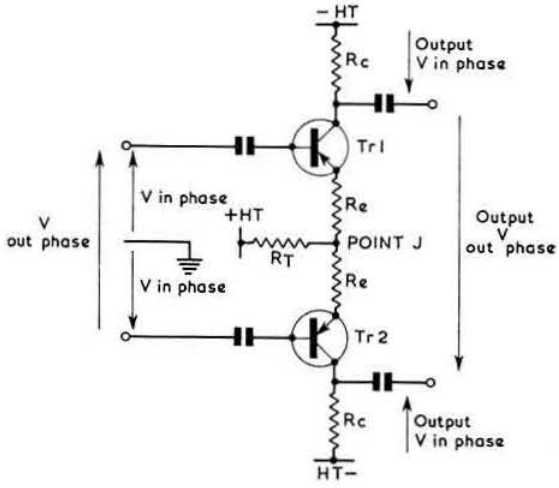

Fig. 17. Out phase signals of the emitter coupled pair. R_b is not shown. The h.t. lines are well decoupled.

(viii) Push-pull signals (out-of-phase) are fed in between the two bases and appear across the two collectors as shown in Fig. 17. For true out-of-phase signals there is no current change through R_T, since the increase of current in Tr1 is

(*Continued on page 547*)

was well remembered by many of those present at the ceremony. He then unveiled the plaque which had, up to then, been covered by the black and gold call-sign flag which G2NM flew from his house at Bosham, Sussex.

A close-up of the commemorative plaque placed on the outside of the house in Caterham, Surrey, from which the late Gerald Marcuse made his pioneer broadcasts to the British Empire.

Harry Clark (G6OT) thanked the Chairman of the Council for performing the unveiling ceremony and on behalf of Mrs. Irene Marcuse and her family, as well as on behalf of all those who had contributed to the Marcuse Memorial Fund, he thanked Mr. A. P. Bodiley, the present owner of "Coombe Dingle," for his kindness in permitting the plaque to be fixed to the wall of his house. Mr. Clark also thanked Mr. and Mrs. Bodiley for their hospitality in providing tea for those who had assembled for the ceremony.

Among the very large company present were Alan Fawcett (G2HQ), Arthur Milne (G2MI), W. E. F. Corsham (G2UV), Victor A. Sims (G5VS), Stanley Cook (G5XB), John Vaughan (G3DQY), J. Sharples (G3FJ) and May Gadsden.

The Gerald Marcuse Memorial Award

AT the fourth Annual Reunion of the Radio Amateur Old Timers' Association held in London on April 6, 1962, the Chairman (Mr. H. A. M. Clark, G6OT) gave details of the Gerald Marcuse Memorial Award. The terms of the award are as follows:

(1) The Award shall be made annually in April (beginning 1963) to the United Kingdom licensed radio amateur under 21 years of age on December 31 previously who shall have submitted to the Radio Amateur Old Timers' Association the most meritorious article describing a piece of equipment which he shall have constructed and used in his station, or a journey which he shall have made during the previous twelve months to a Commonwealth or foreign country where he met and visited other licensed radio amateurs. Entrants must be Corporate members of the Radio Society of Great Britain.
(2) The manuscript of the article shall be either typed, using double spacing, or written legibly on lined foolscap.
(3) All manuscripts shall be judged by a panel consisting of three members of the Association.
(4) The closing date for entries shall be January 31.
(5) The winner of each Award will be invited to attend the Annual Reunion of the Association as a guest of the Association.
(6) The Award will take the form of books or book tokens to a value of not less than two pounds.
(7) The winning manuscript will be offered to the Editor of the R.S.G.B. BULLETIN for publication.

Simple Transmitting Aerials (Continued from page 528)

coupling loop can be a few turns wound over the centre o the coil.

Any convenient length of co-axial cable may be used to connect the transmitter to the tuner. The same circuit will enable a half-wave end-fed aerial to load the transmitter. There is then only one lead from the tuner to aerial, instead of the two shown in Fig. 3. This lead (the TX end of the aerial) can be tapped along the coil, if necessary, to secure correct loading of the transmitter. The centre of the coil (dotted line) should be earthed; alternatively a two-gang or split stator capacitor with the moving plates connected to earth, and one set of fixed plates connected to each end of the coil, can be used for the end-fed aerial.

For series tuning a Zepp feeder or tuned dipole feeder, place the capacitor in one lead, instead of in parallel with the coil. Note the number of turns found best, or fit a switch or tags, for easy selection.

It need scarcely be added that increasing the height of the aerial, and keeping it clear of walls, buildings, and other earthed objects, will help to improve signal radiation.

Transistor Circuit Design Made Easy (Continued from page 532)

obtained from a corresponding decrease in Tr2. Thus point *J* does not change in voltage.

Then by an argument similar to the single ended voltage amplifier

$$\textit{Out-of-phase gain} = \frac{\textit{Output } v}{\textit{Input } v} \simeq \frac{2R_e}{2R_e} \simeq \frac{R_c}{R_e}$$

Hence $R_e = R_c/\textit{Out-of-phase gain}$

However, for unwanted in-phase signals, the circuit may be redrawn as in Fig. 18 where

$$\textit{In-phase gain} \simeq \frac{\frac{1}{2}R_e}{R_T + \frac{1}{2}R_e}$$

Since R_e is small compared with R_T

$\textit{Gain} \simeq R_e/2R_T$

Since R_T may be equal to or larger than R_e, there can be fractional gain to in-phase signals, while still having large gain to out-of-phase signals. This discriminates against in-phase signals to the benefit of out-of-phase signals.

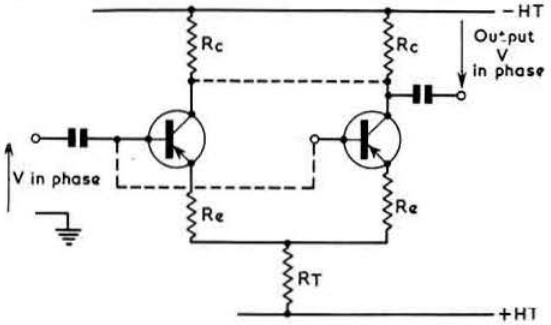

Fig. 18. In-phase signals of the emitter coupled pair.

(To be concluded)

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